An Overview of Recognizing High Impact Hydro Events

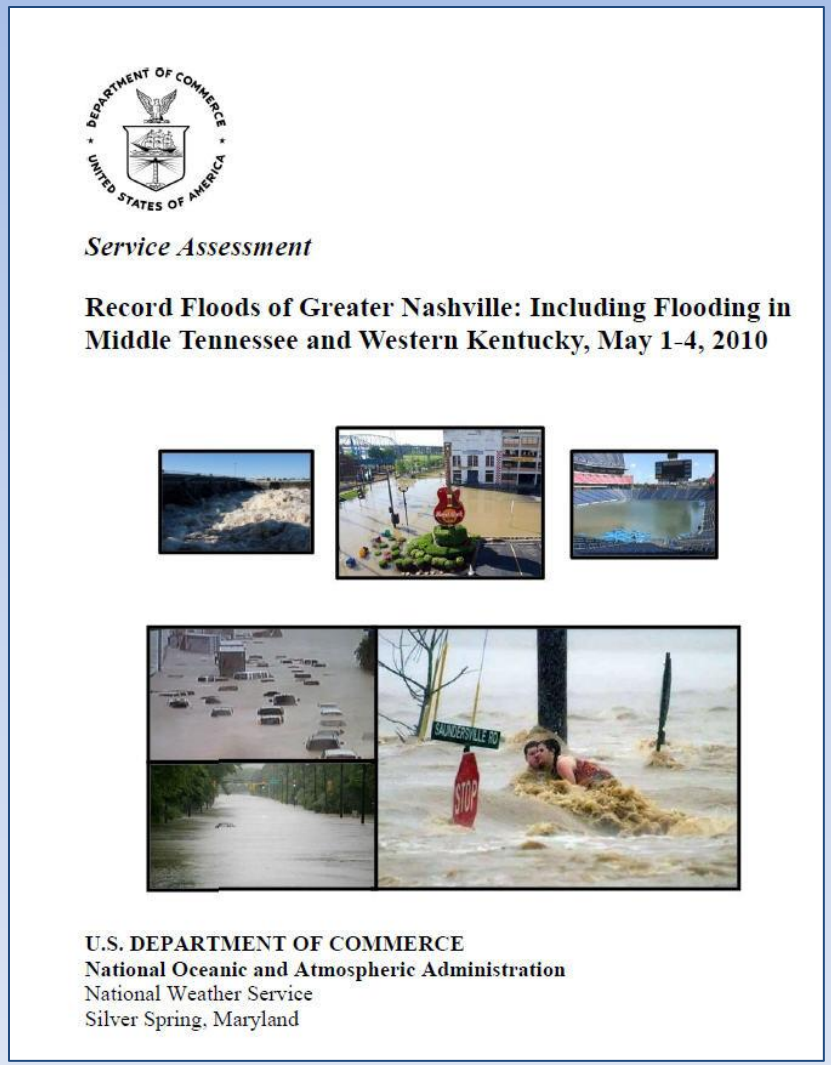
By Richard H. Grumm
WFO State College PA

Facilitators: Brad Grant, Steve Martinaitis

Learning and Performance Targets

Recommendation 12:

Training should be enhanced on the use pattern recognition for extreme events and use of anomaly data and SREF data in the forecast process.



Service Assessment

Record Floods of Greater Nashville: Including Flooding in Middle Tennessee and Western Kentucky, May 1-4, 2010

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Weather Service
Silver Spring, Maryland

Learning and Performance Targets

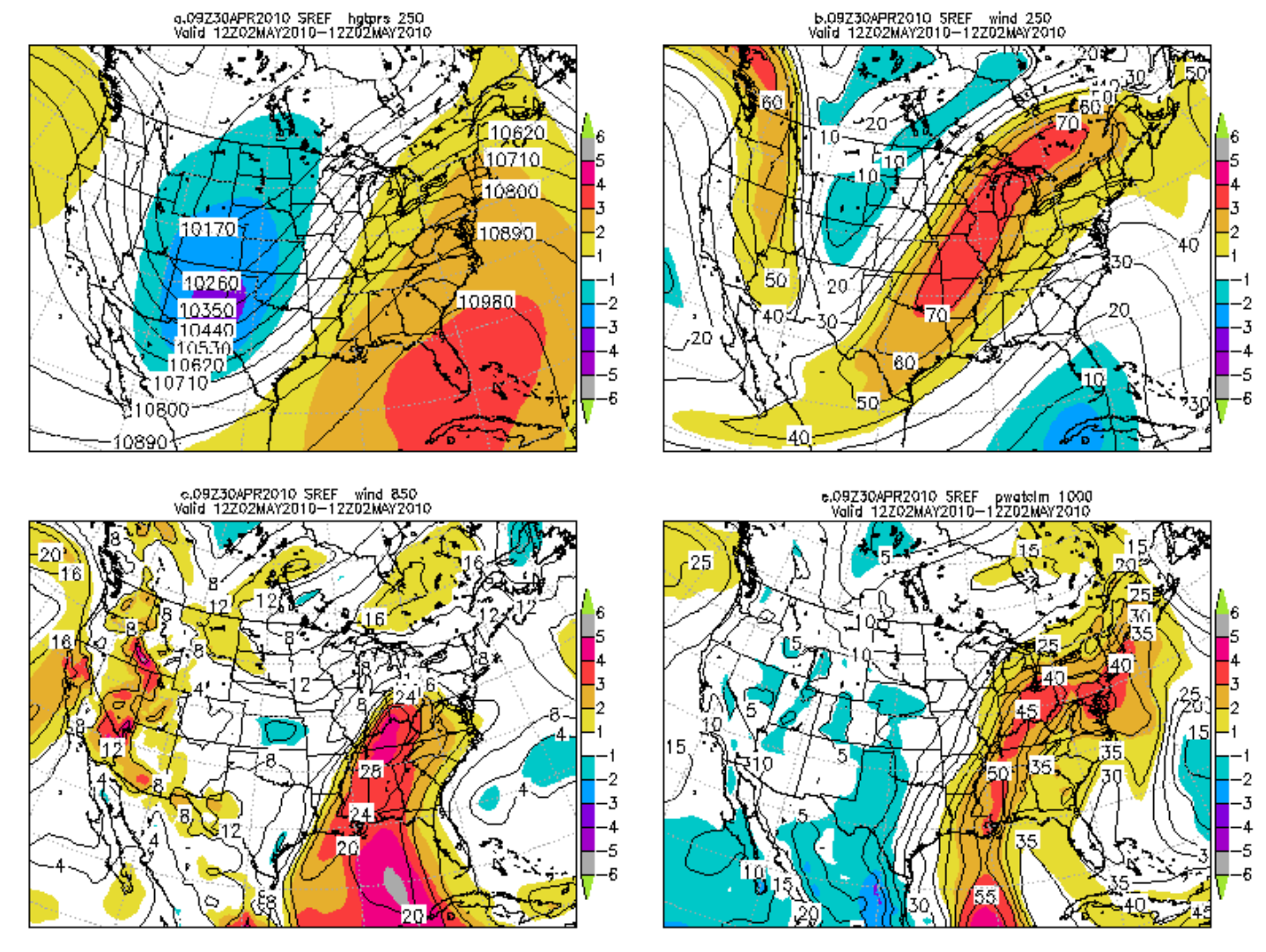
All NWS meteorologists and hydrologists shall be able to:

1. Identify role of antecedent conditions in flood events.
2. Show how well standardized anomalies aid in identifying the potential for heavy rain and flooding.
3. Recognize the limits of standardized anomalies in the forecast process and in heavy rainfall events.
4. Show how standardized anomalies and ensembles can provide confidence in forecasting flood events.

Outline

- **Focus on using standardized anomalies**
  - Identify heavy rainfall events that can produce forecasts of heavy/excessive rain
  - Strive for identification of enduring/multi-day events
  - Method can be applied for a spectrum of weather events
- **Ensemble anomalies and QPF**
  - Confidence in a known pattern
  - Provide some information on predictability
- **Future guidance** → Moving toward Extreme Forecast Index (EFI) and alarm maps

Ensembles Provide Anomalies and Confidence in the Outcome of a Pattern



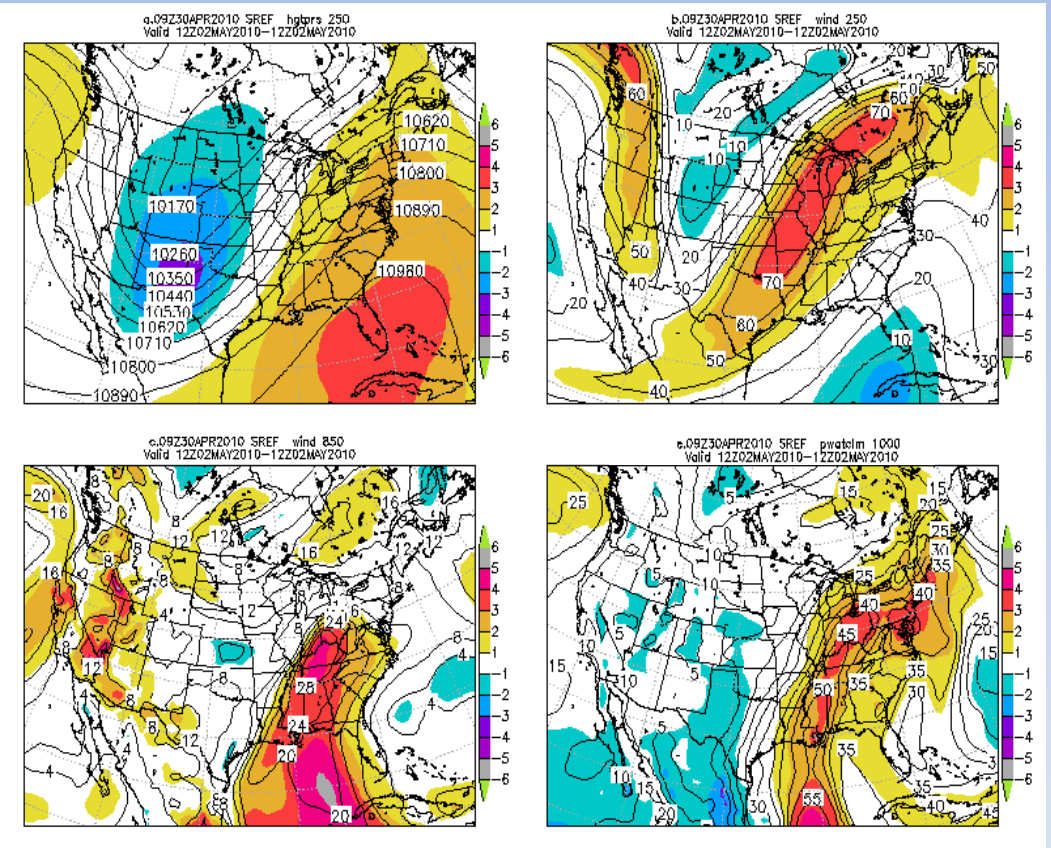
Anomalies, Patterns and Ensembles

How are these related?

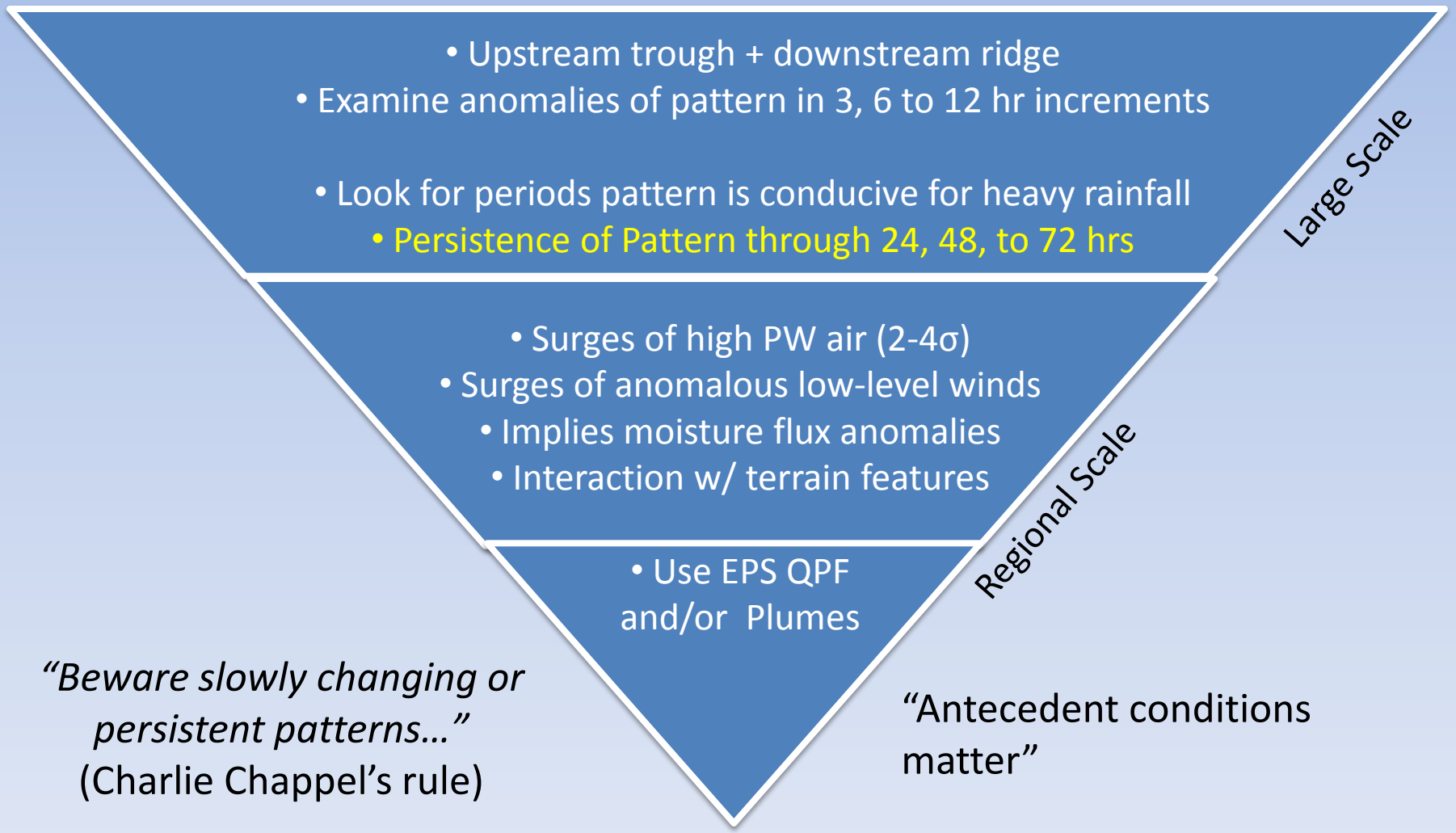
- **Anomalies** and the known **Patterns** distinguish an ordinary from an extraordinary event
- Known **pattern** + large **anomaly** provide confidence in predicting **high impact events**
- **Ensembles** add the **confidence information** related to probability of exceeding a certain QPF or anomaly value

What's the Applicability?

- **Confidence** in the pattern
  - Deep trough and ridge with moisture plume (Atmospheric river)
  - Large PW anomalies with strong low-level winds
- Provide context of pattern (***Maddox Types***)
  - Known pattern with high probability of above normal PW and low-level winds
  - Signal that **this event** could be bigger than most heavy rain events of this type



Forecast Funnel Considerations



"Beware slowly changing or persistent patterns…"
(Charlie Chappel's rule)

"Antecedent conditions matter"

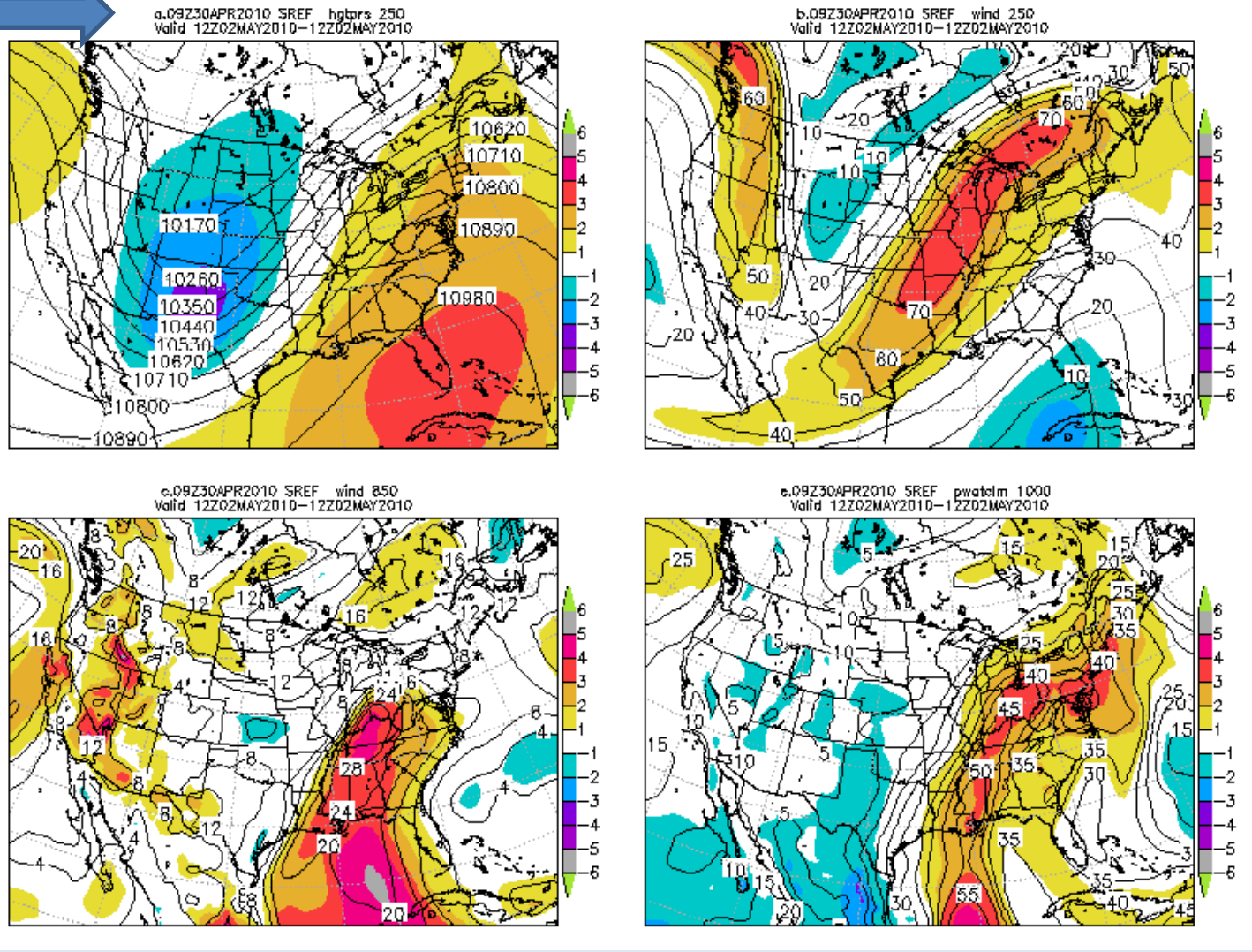
A Snap Shot Fade to 24-hour

Persistent heavy rain pattern → Chapell's Rule

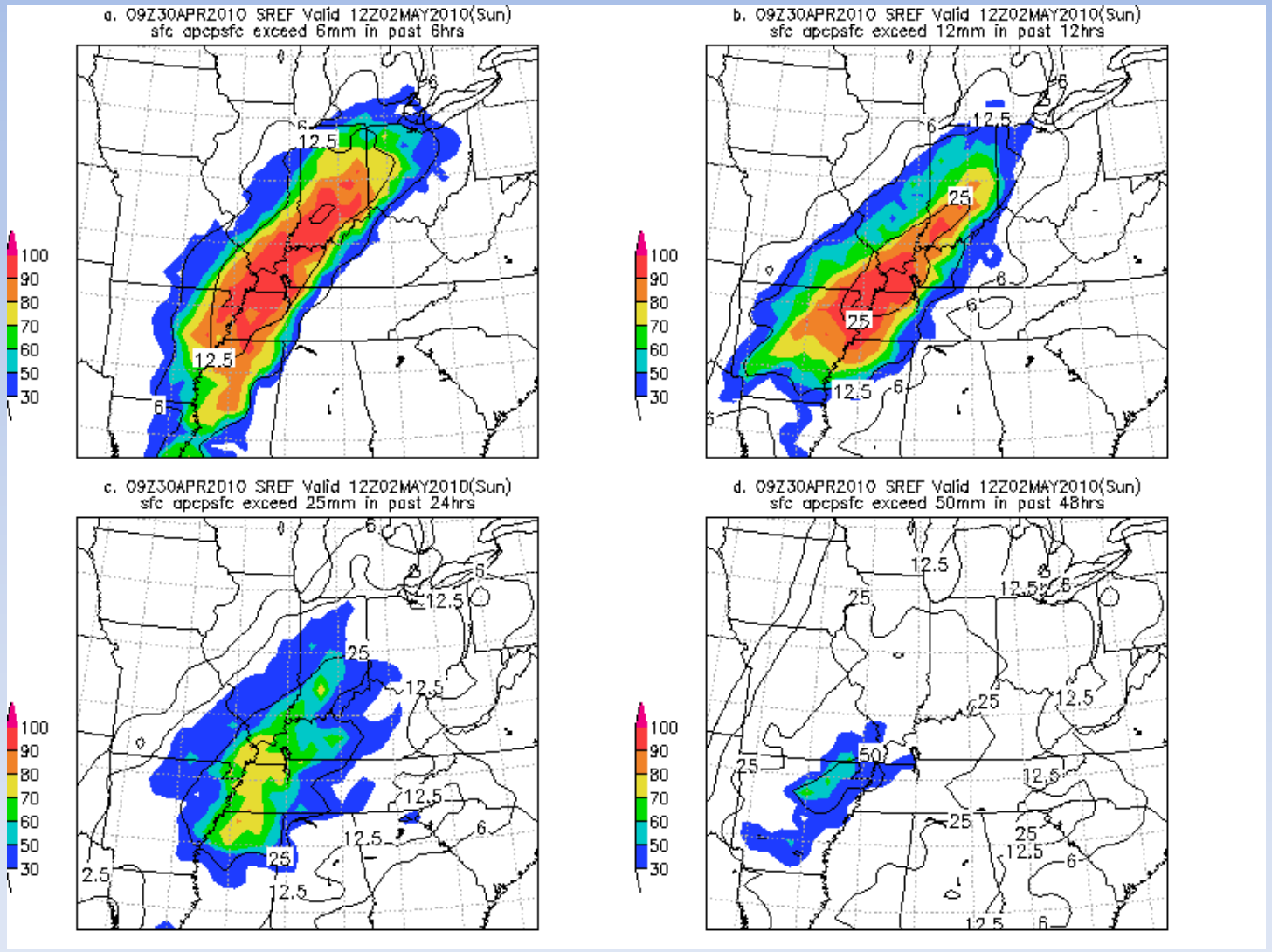
Time of image

Analyze pattern over a 24-hr period (in this case, the period ending at 00 UTC 03 May 2010)

Persistence of a known heavy rainfall pattern



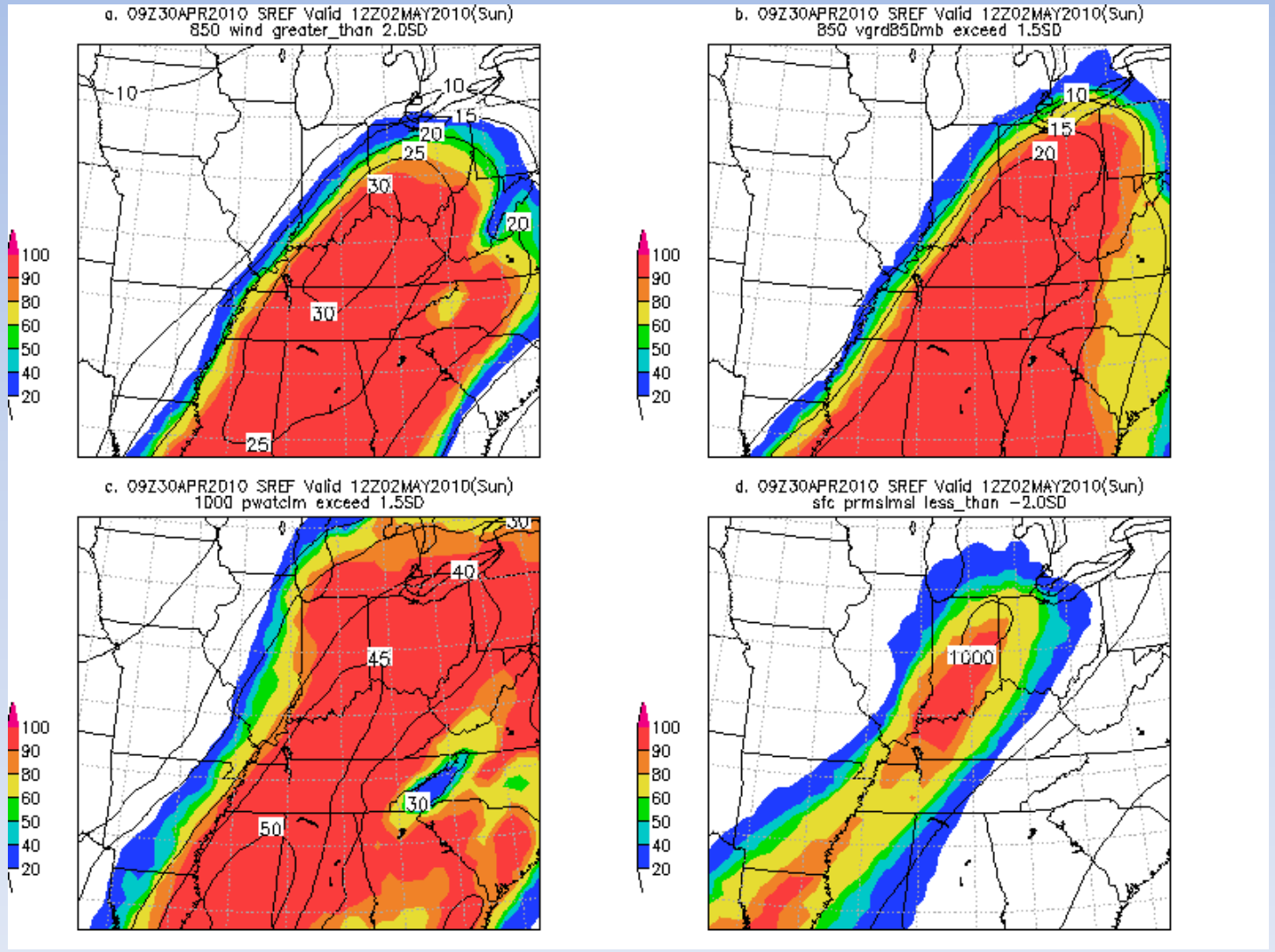
Where it rains, when it rains and how much it rains



Previous QPFs show heavy rainfall potential

- High probability of heavy rainfall in Mid-Mississippi Valley
  - Other thresholds would be good
  - Fairly long range location could shift!
- We need reinforcing regional data
  - Pattern and key parameters conducive for heavy rainfall?
  - Anomalies for context (significant event)
  - Ensembles for confidence in the pattern
- Things we do not know
  - Internal system QPF climatology
  - What is a 80, 90% or record rainfall in the SREF, GEFS, NAM?
    - Do you have a “feel” for this?

Rainfall and Heavy Rainfall from High Probability Anomalous Pattern



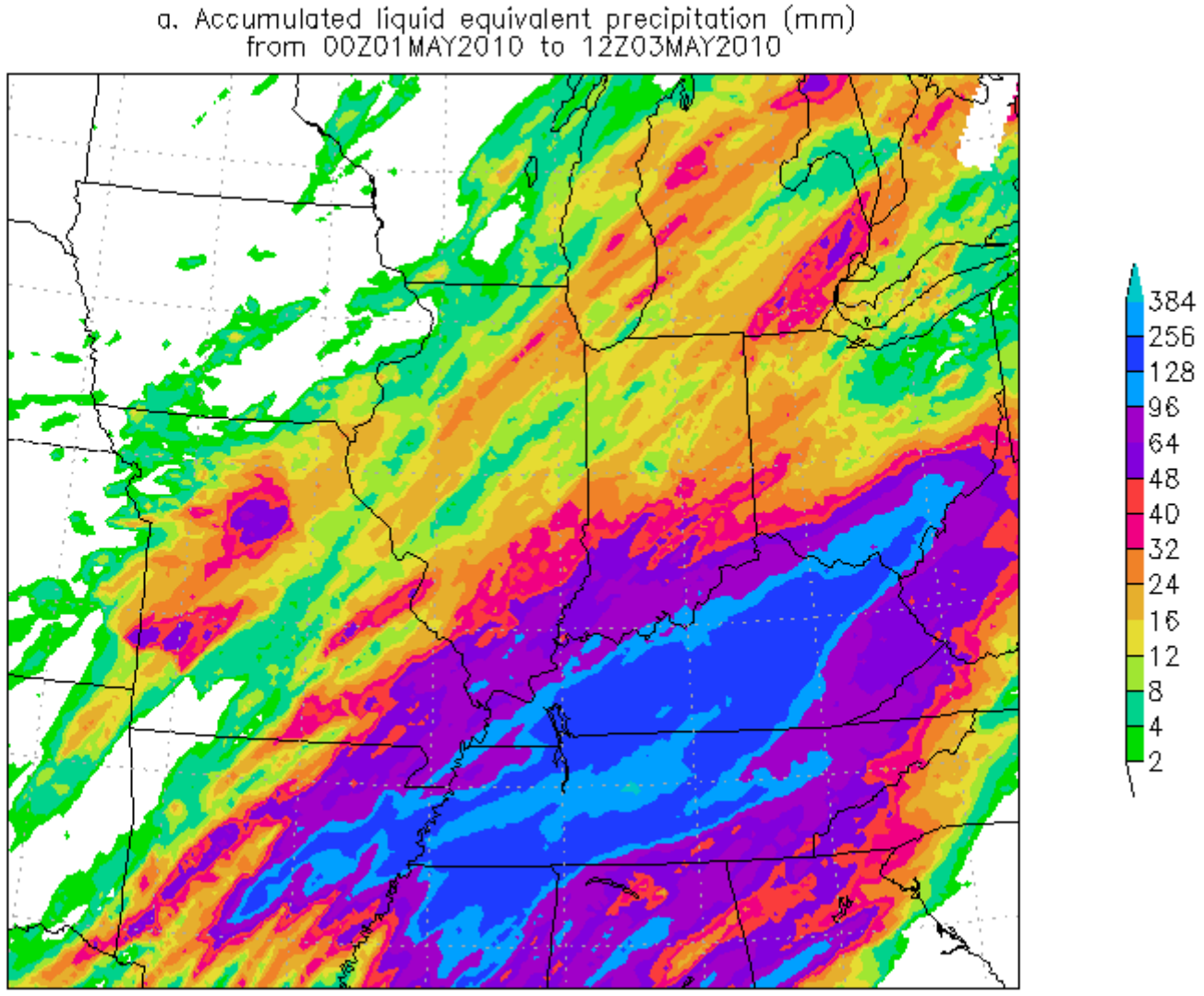
Persistent Surges in High PW Air and Strong Low-level Winds

- Large scale pattern showed common event type
  - Anomalous trough-ridge and surging AR into MMV
  - This pattern forecast to persist for over 24 hours
- SREF showed high probability relatively heavy rainfall
- Regional scale anomalies
  - Put this pattern into **contex**t with confidence based on high probabilities of anomalous pattern
  - Enduring period of anomalous PW and V-winds into region→ Confidence in heavy rainfall
- Anomalies for context and Ensembles for confidence
  - Some reinforcing data (GFS/GEFS/NAM)

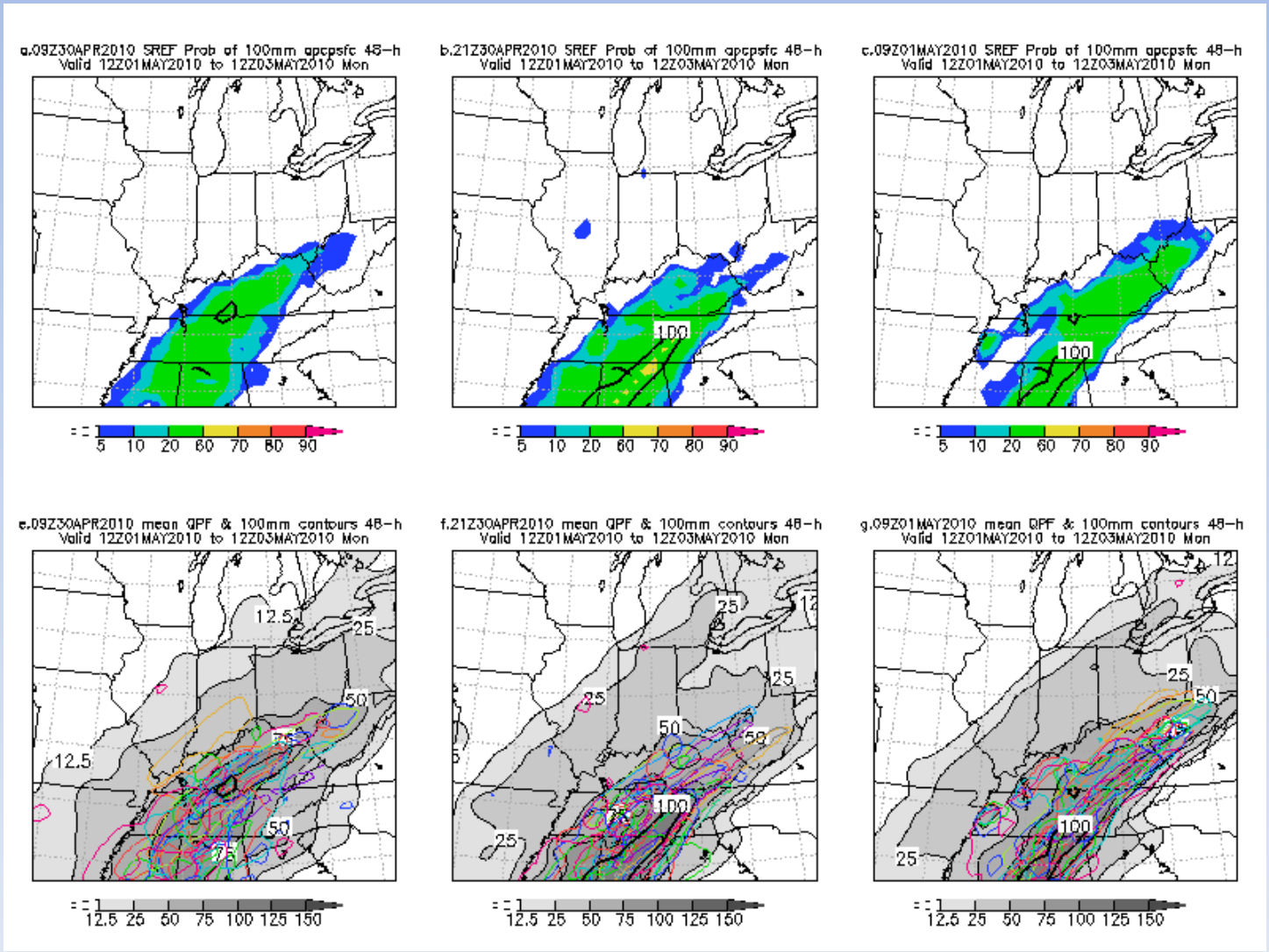
The Simple Anomaly Context

Pattern	**Event Type**	**Anomalies**
Moisture plumes ("Atmospheric Rivers")	High end heavy rain	2 to 4σ PW
Strong poleward flow	Synoptic	3-5σ v-wind
Strong easterly flow	TC or Frontal	3-5σ u-wind
Simplistically high moisture/High wind	Big rainfall Extreme	2 to 4σ Moisture Flux 5 to 6σ Moisture Flux

Estimated Rainfall (Stage IV Data Verification)

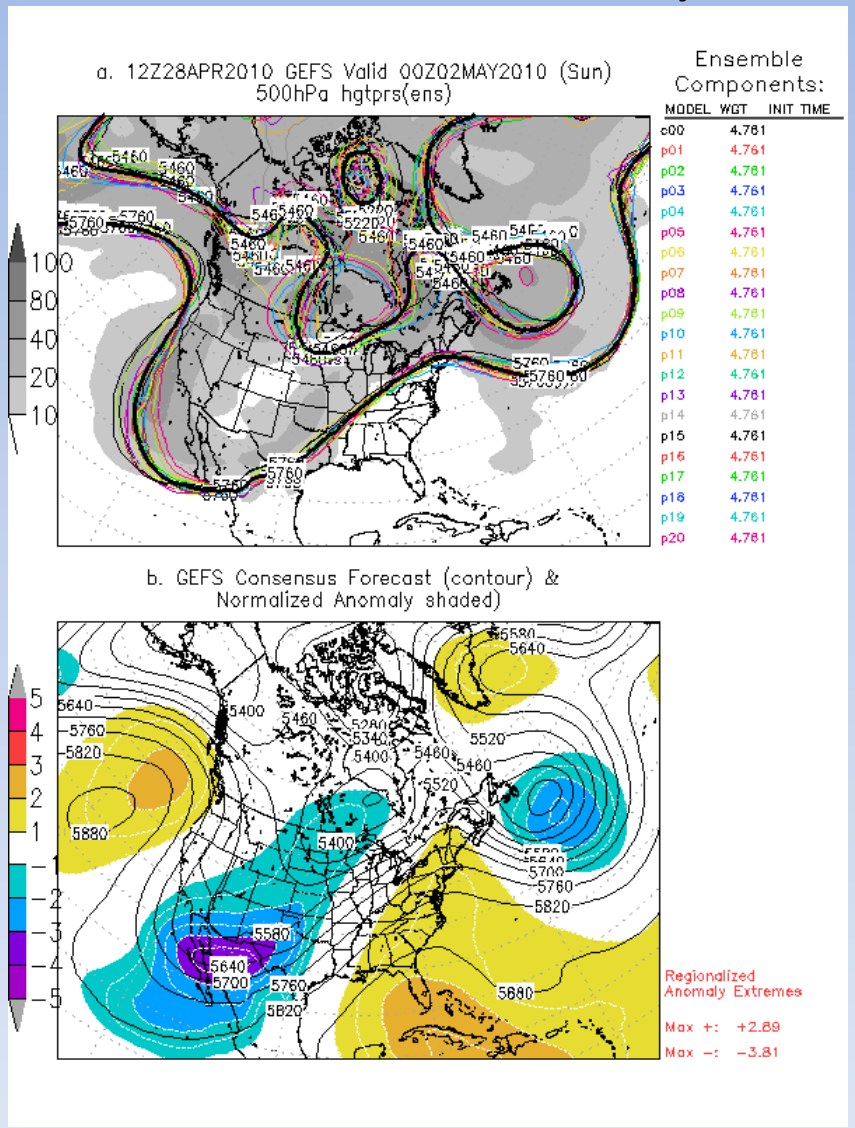


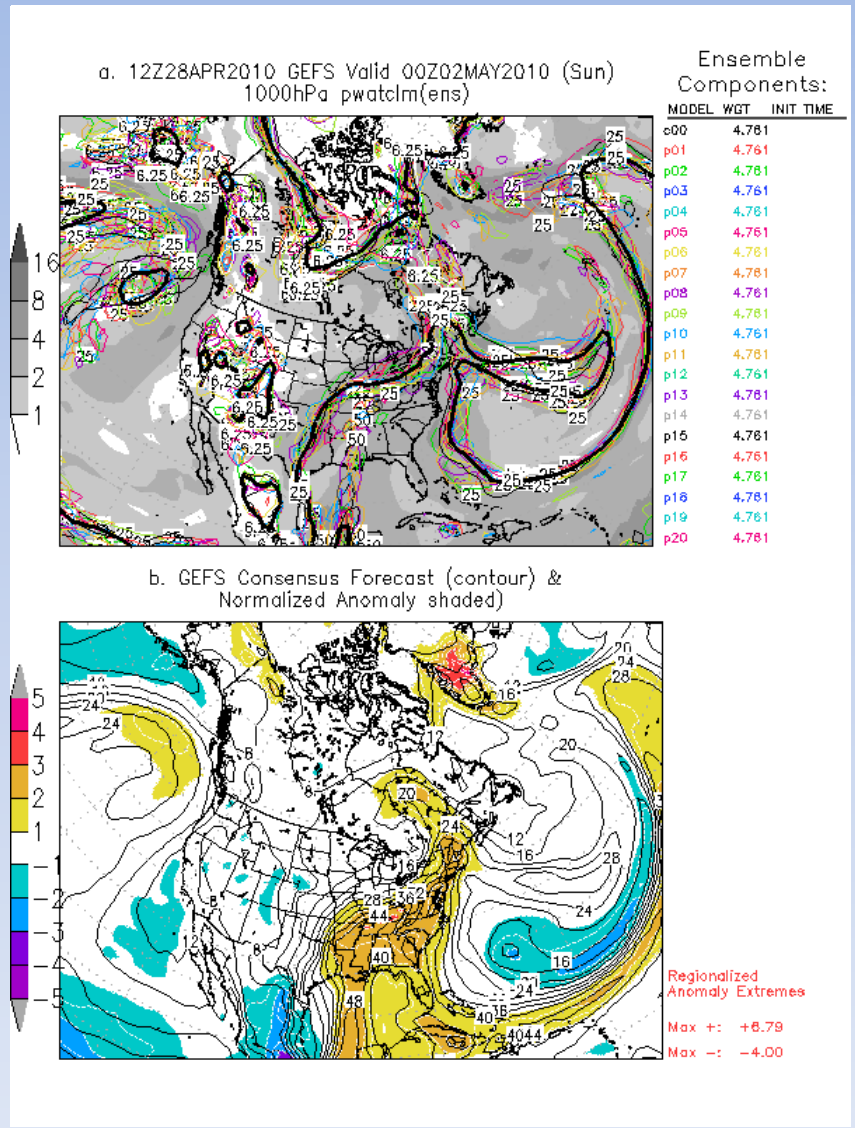
SREF Probability of 2,3 and 4 inches



GEFS 500 and PW forecasts

Established heavy rainfall pattern → funnel down





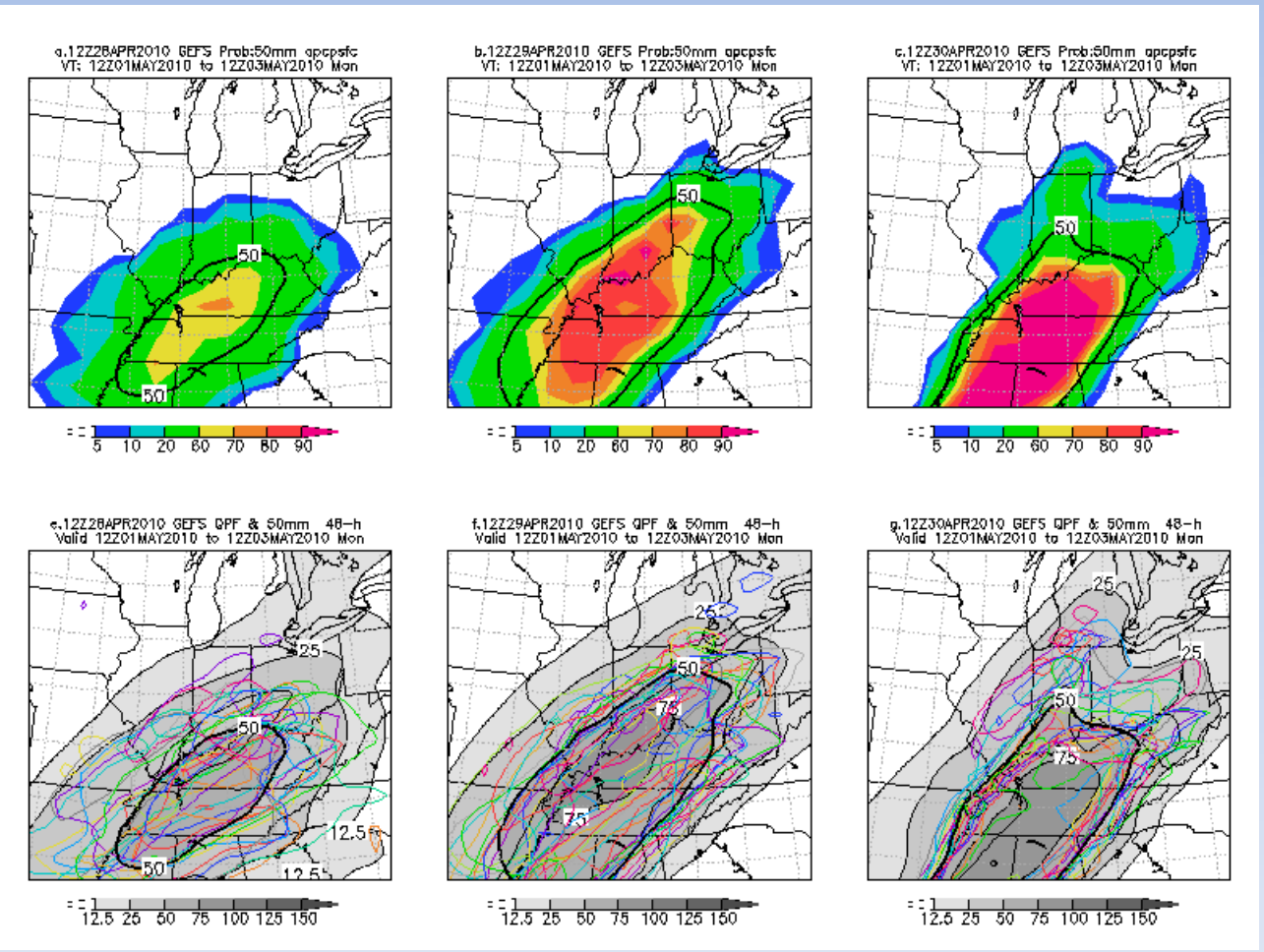
GEFS 500 and PW forecasts

Established heavy rainfall pattern → funnel down

- Great Pattern and zoom in focused over MMV
  - Plume high PW air
  - Though not shown winds were anomalous too
- Key role flow about anomalous ridge and trough
  - Funnel approach is helpful (extremely)
  - Leverage synoptic and pattern skill→ anomaly context
    - Zoom into to get detail and region of impact
    - Works great for synoptic forced and widespread events

Tie in Patterns and Probabilities

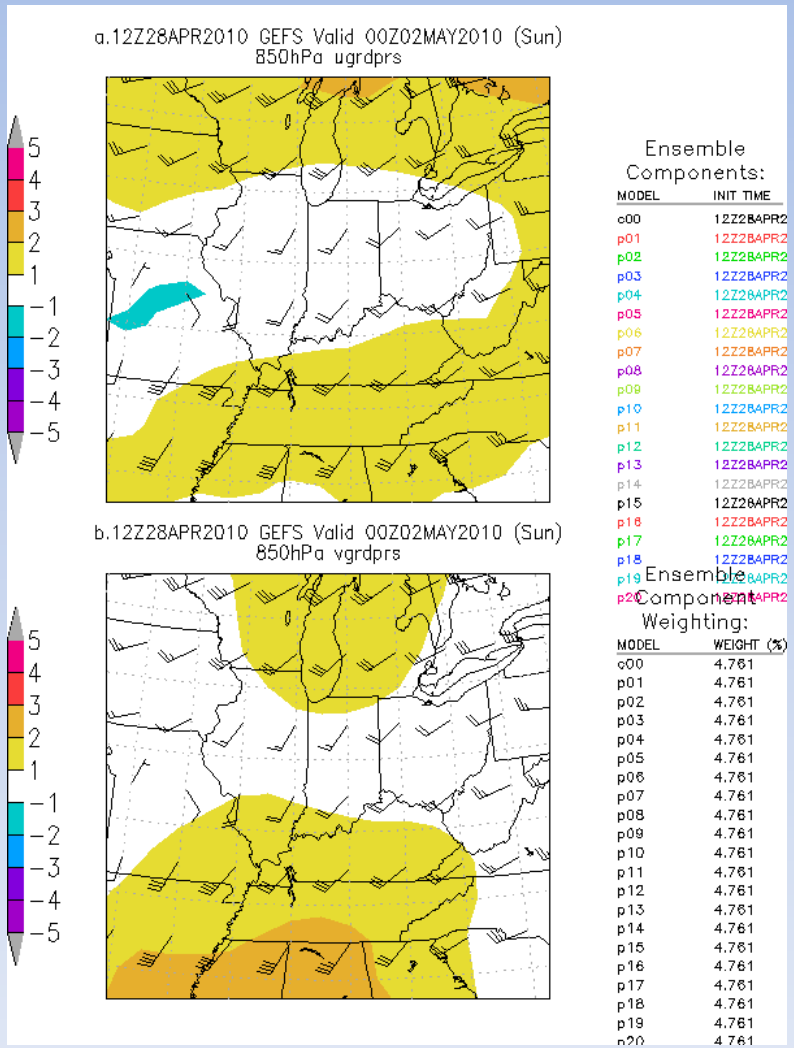
GEFS runs 12Z 28-30 April 2010 48 hr QPF VT00Z 3 May 2010

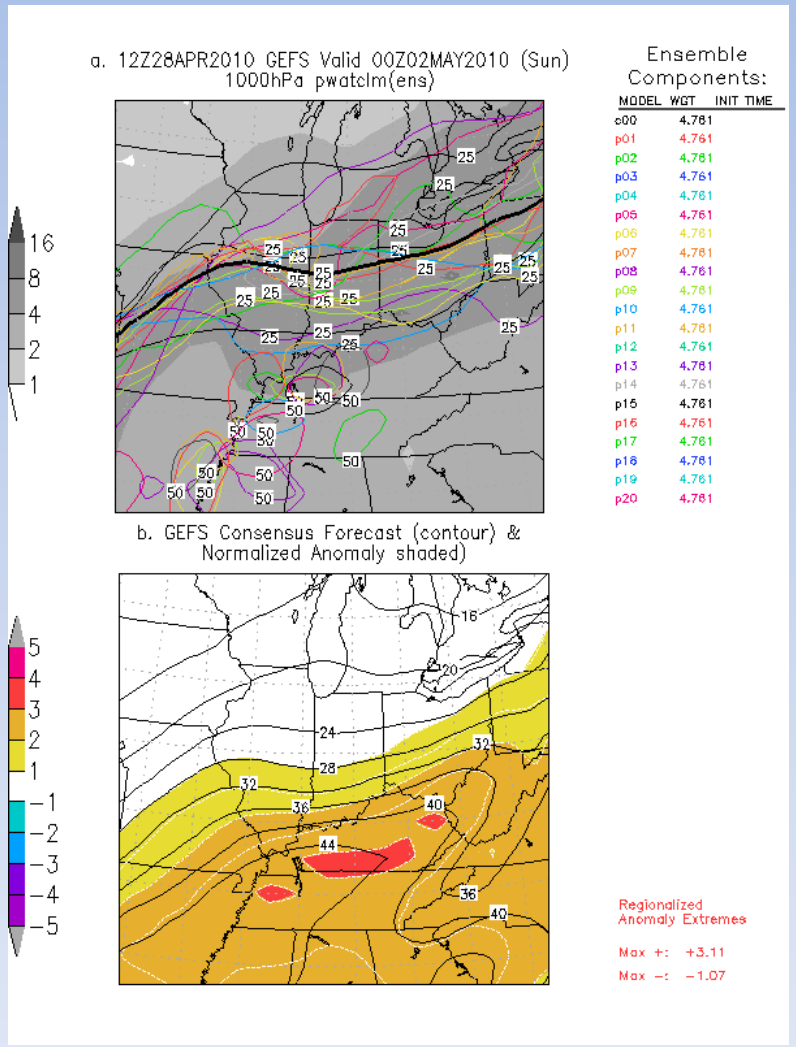


- 3 runs 24 hours apart
  - Latter more skillful
- Exceedance
  - 50, 75, 100 mm
  - 2,3, 4 inches
- GEFS 75km
  - What is a big QPF in the GEFS? GFS? SREF?
- Pattern for heavy rain
- Probability big QPF
- **Patterns & Probabilities**

Successive Forecast High PW

High PW air and strong low-level winds → High QPF

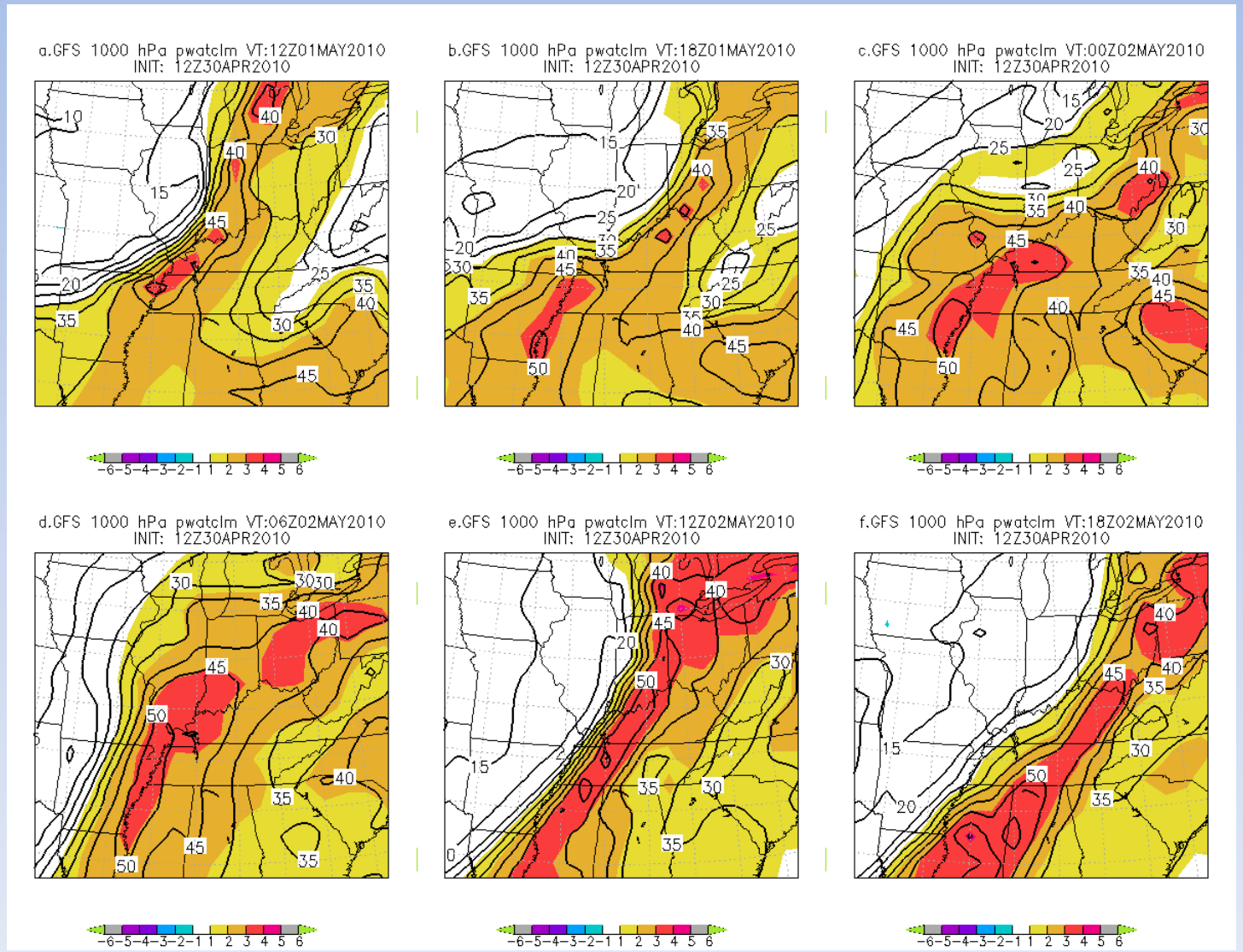




Deterministic High Resolution Models

- Larger anomalies
  - One model and no averaging uncertainty information is lost
  - Finer scale verse our EFS and climatology
- Higher resolution
  - Aids in predicting the potential for higher end events
  - Extremely useful extremes and valuable at shorter ranges

GFS Regional Pattern and Anomalies with QPF



Deterministic High Resolution Models

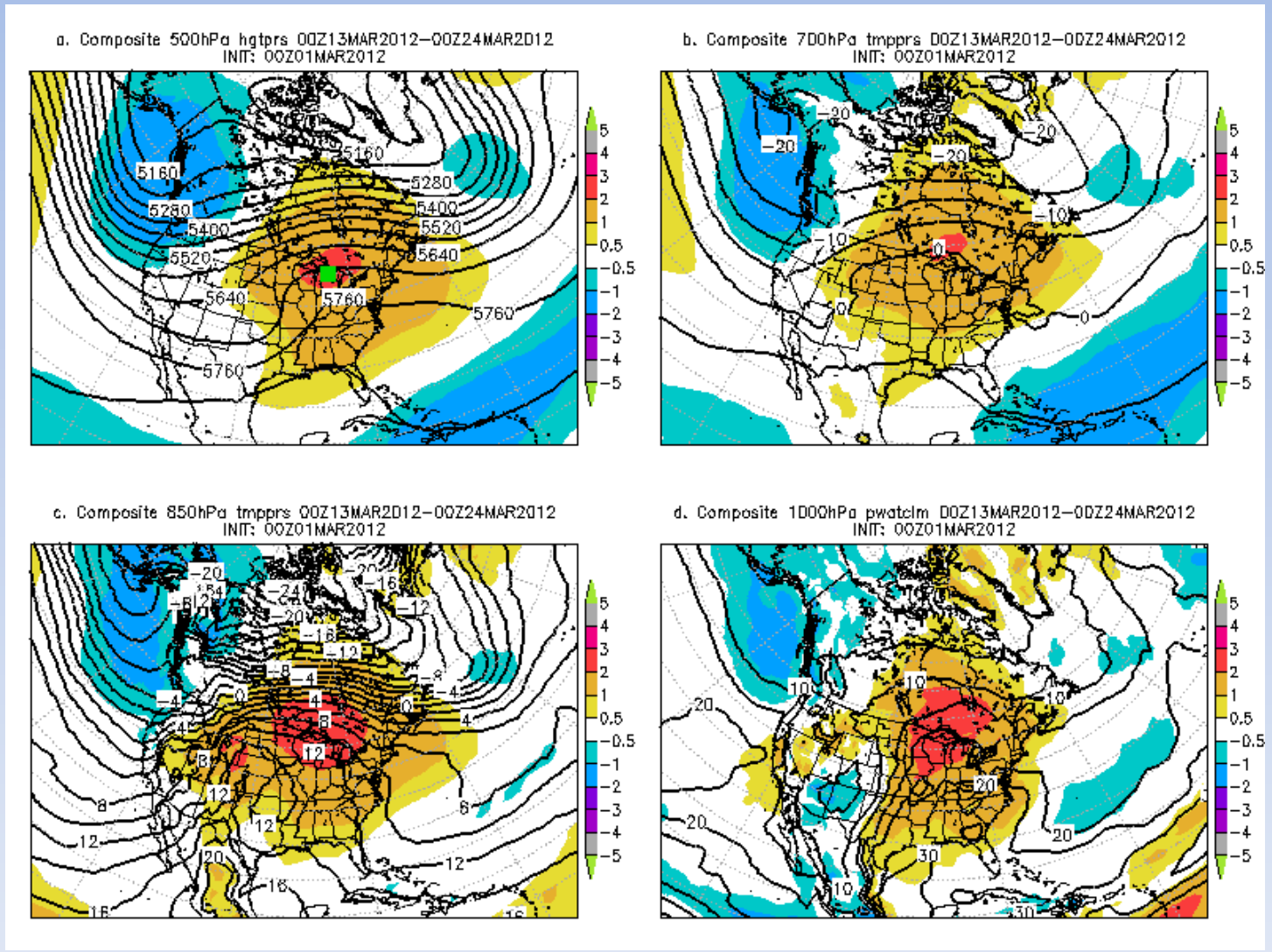
- Show uncertainty when examined run-to-run
- Increase in value as forecast length decreases
  - Valuable shorter ranges strongly forced systems
- In 0-18 hour range→
  - 3-4 km models very useful and storm scale ensembles should help in ***strongly forced larger scale events***
- Limitations with more mesoscale events

Limitations

Predictability is a hurdle we may never clear

- Method good for pattern and pattern recognition
- Larger scale events with strong signal
  - Well predicted but not the exacting details and
  - Not the exact region errors of ~100km are typical
- Mesoscale events (Chicago Flood 2011 example)
  - Pattern may look generally good
  - NWP has limited ability to predict locally heavy rainfall
  - Storm scale models & ensembles may help 0-12 hours
    - Problem is the hardest to deal with → job security!
    - Use patterns and MET_WATCH in these cases

Pattern for record warm 9 days and 2 days and 1 time period



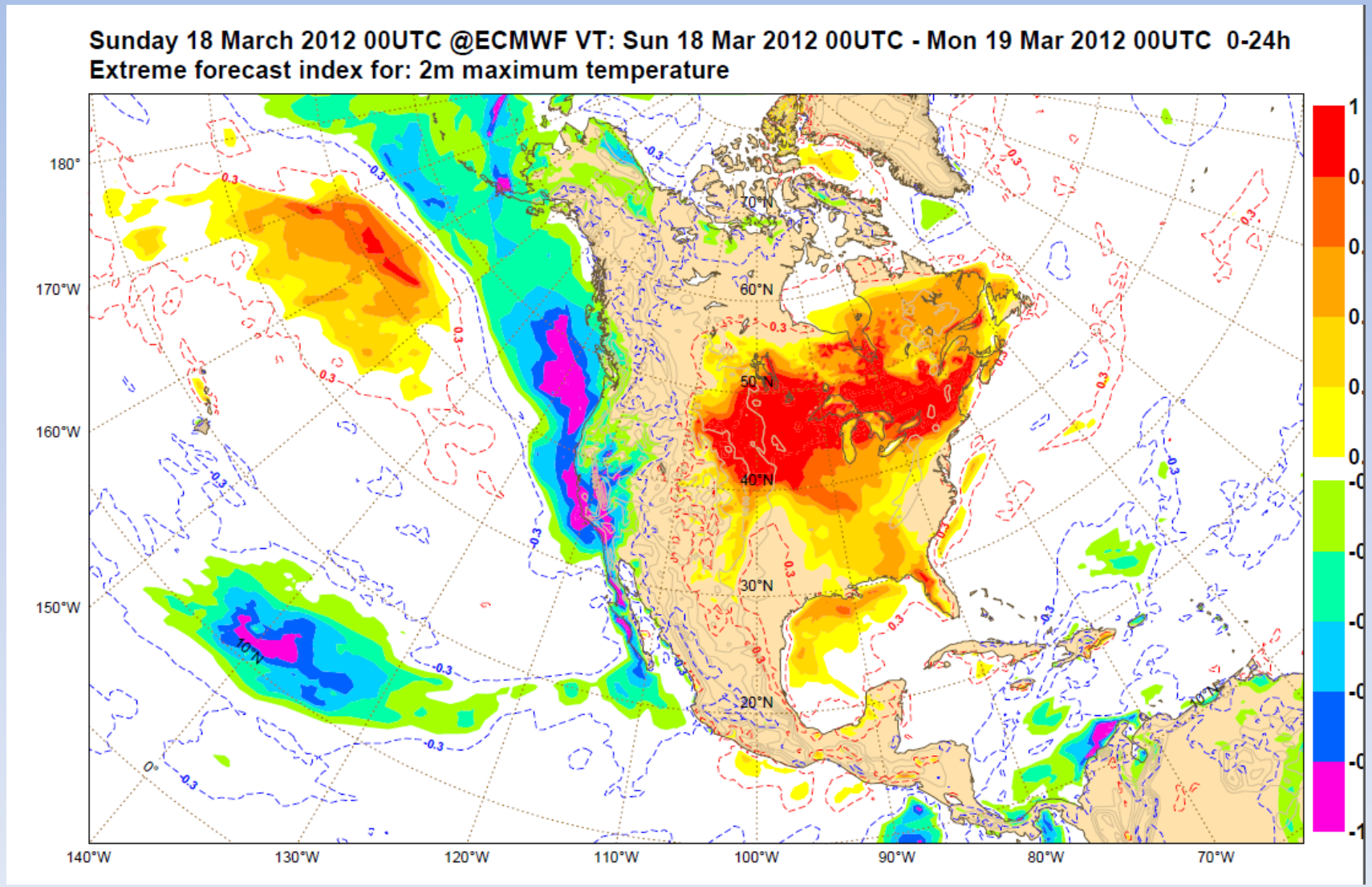
Threats and Extreme Forecast Indices (EFI)

- **Threats** → Probabilities of key parameters exceeding critical thresholds to alert forecaster to outcomes… Can R-Climate based or critical probabilities (SPC does this)

- **EFI** → Alarm bells based on exceeding internal ensemble climatology (M-Climate) or re-analysis climatology (R-Climate)

M-Climate Based EFI

Record high and high minimum temperatures

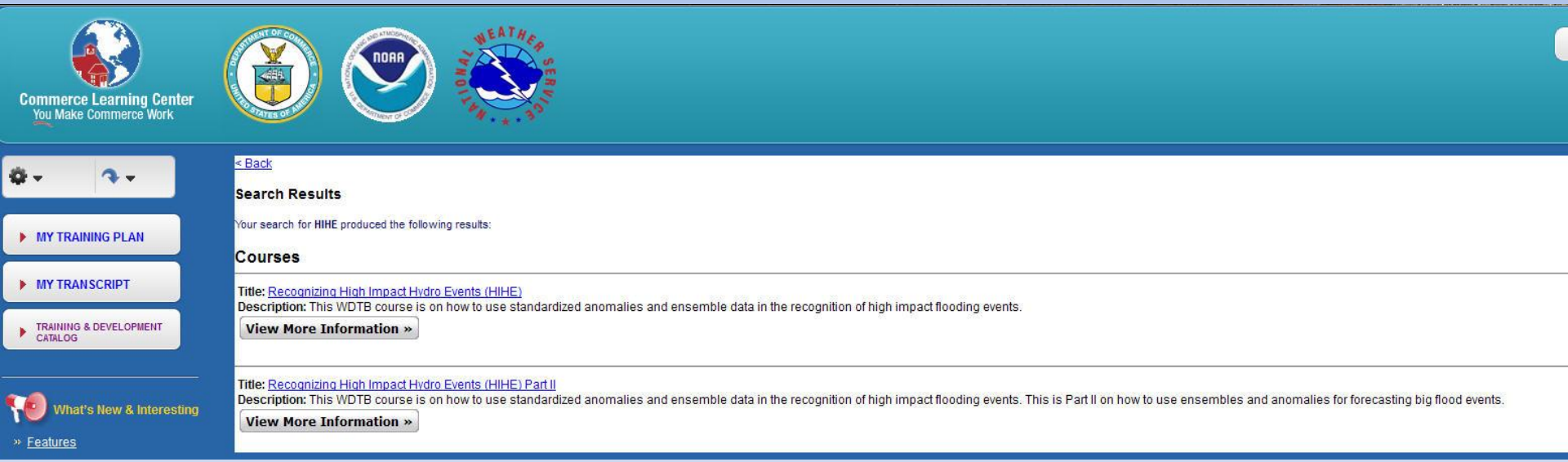


Review

Patterns and Probabilities → HIHE

- Leverage ensemble **confidence information**
  - In the pattern and the persistence of the pattern associated with heavy rain
  - And the probabilities for excessive rainfall
  - To Produce forecasts of heavy of heavy/excessive rain
- Leverage Anomaly information
  - Put known patterns into context → identify HIHE!
  - Provide some information on predictability
- Future →
  - New climatology being derived but we need internal model climate
  - Data into AWIPS
  - More probabilities focused on the threats

Recognizing High Impact Hydro Events Online Course Information



Log into NWS Learn Center (https://doc.learn.com/noaa/nws)

Use Search Tool ("**HIHE**") in Training and Development Catalog

WDTB HIHE Course Website

http://www.wdtb.noaa.gov/courses/hydro

Course Completion Instructions:

1. Complete the pre-requisites for the course:
   - AWOC IC Severe 1 (Conceptual Models) - Lesson 3: **Flash Flooding**
   - Flash Flood Warning Best Practices - Part 3: **The Meteorology Behind Extreme Rain Events**
2. Review optional material that can better your understanding of QPF, NWP models, precipitation estimation, hydrology, and streamflow prediction. A list of relevant material can be found on the **Review Page**.
3. Complete all lessons in **Recognizing High Impact Hydro Events** course, including the case exercises.
4. Complete the course assessment on the **LMS Web Page**.

Course Outline:

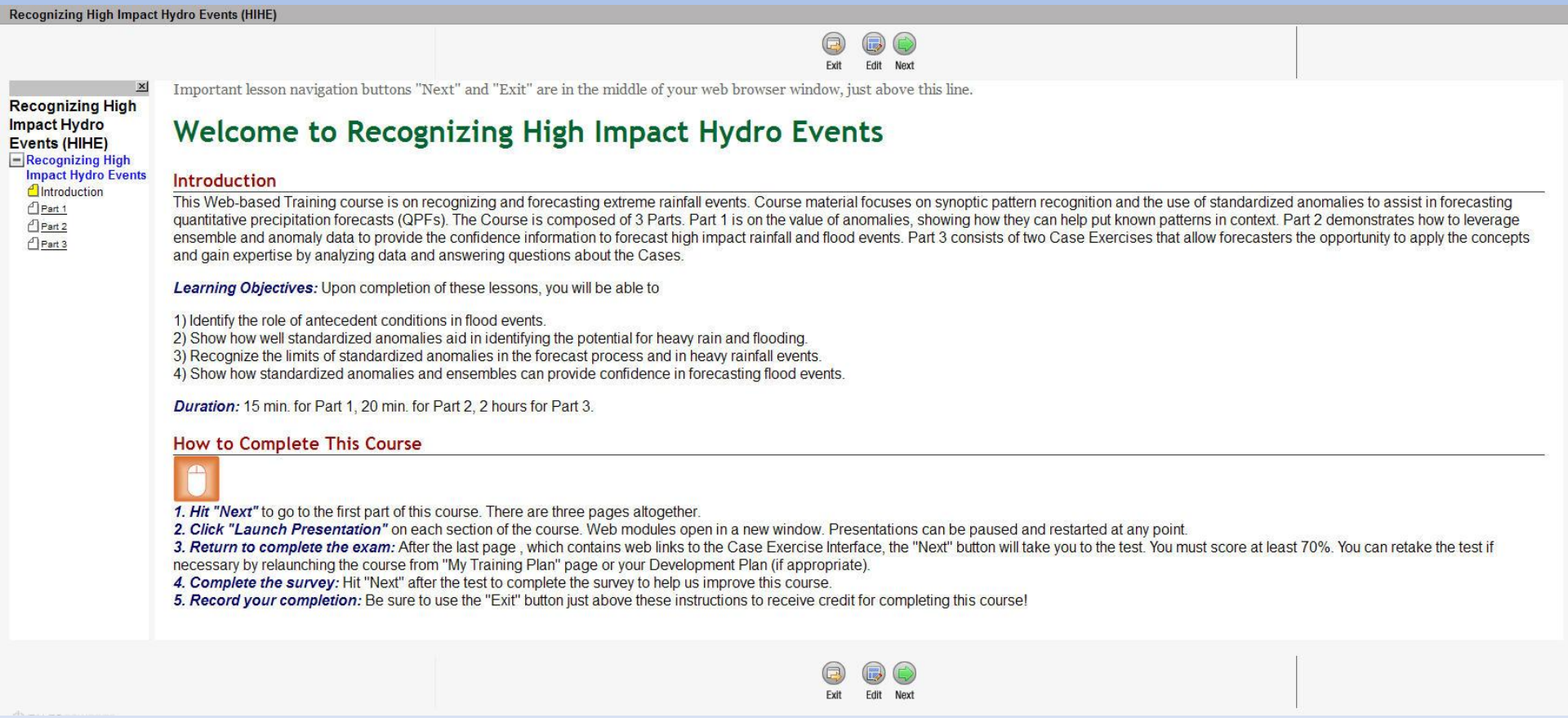
Use the tabs below to view the details on each part of this course. You have the ability to view or download the presentations and exercises from here. Remember to login to the LMS to receive credit for the Course and the Case Exercises.

Overall Course Duration: 140 minutes

- **Part 1: On the Value of Anomalies**
- **Part 2: Ensembles and Anomalies**
- **Part 3: Case Exercises**

Performance Objectives for Course:

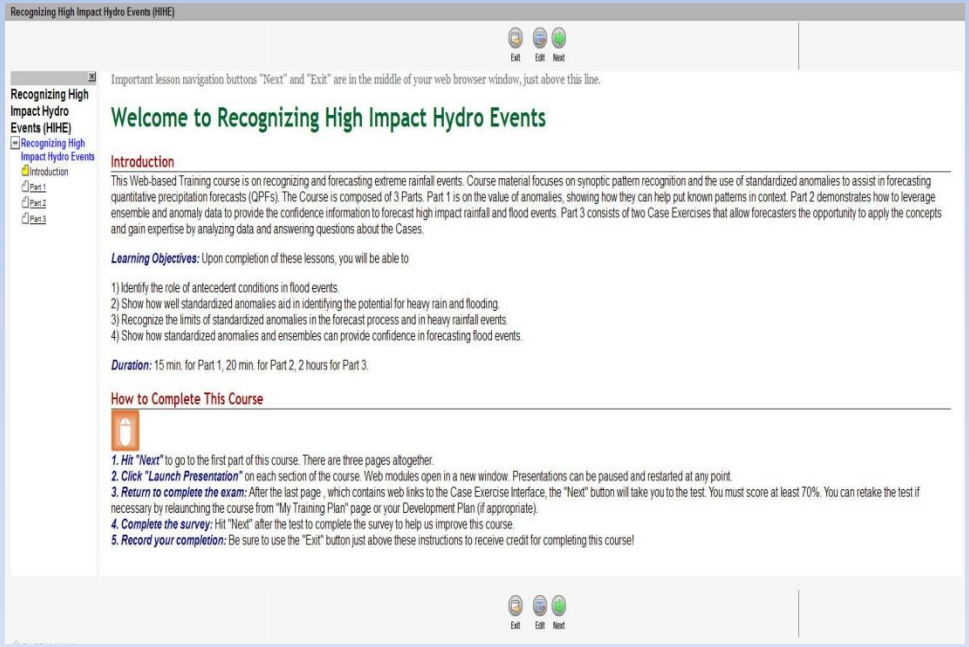
LMS Course

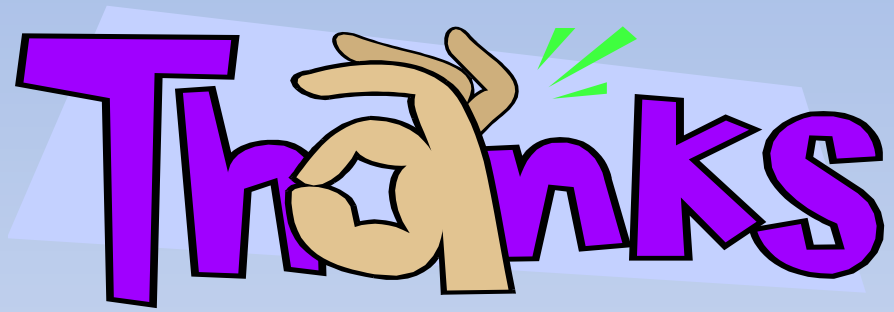

Recognizing High Impact Hydro Events (HIHE)
Exit
Edit
Next
Recognizing High Impact Hydro Events (HIHE)
Recognizing High Impact Hydro Events
Introduction
Part 1
Part 2
Part 3
Important lesson navigation buttons "Next" and "Exit" are in the middle of your web browser window, just above this line.
Welcome to Recognizing High Impact Hydro Events
Introduction
This Web-based Training course is on recognizing and forecasting extreme rainfall events. Course material focuses on synoptic pattern recognition and the use of standardized anomalies to assist in forecasting quantitative precipitation forecasts (QPFs). The Course is composed of 3 Parts. Part 1 is on the value of anomalies, showing how they can help put known patterns in context. Part 2 demonstrates how to leverage ensemble and anomaly data to provide the confidence information to forecast high impact rainfall and flood events. Part 3 consists of two Case Exercises that allow forecasters the opportunity to apply the concepts and gain expertise by analyzing data and answering questions about the Cases.
Learning Objectives: Upon completion of these lessons, you will be able to
1) Identify the role of antecedent conditions in flood events.
2) Show how well standardized anomalies aid in identifying the potential for heavy rain and flooding.
3) Recognize the limits of standardized anomalies in the forecast process and in heavy rainfall events.
4) Show how standardized anomalies and ensembles can provide confidence in forecasting flood events.
Duration: 15 min. for Part 1, 20 min. for Part 2, 2 hours for Part 3.
How to Complete This Course
1. Hit "Next" to go to the first part of this course. There are three pages altogether.
2. Click "Launch Presentation" on each section of the course. Web modules open in a new window. Presentations can be paused and restarted at any point.
3. Return to complete the exam: After the last page , which contains web links to the Case Exercise Interface, the "Next" button will take you to the test. You must score at least 70%. You can retake the test if necessary by relaunching the course from "My Training Plan" page or your Development Plan (if appropriate).
4. Complete the survey: Hit "Next" after the test to complete the survey to help us improve this course.
5. Record your completion: Be sure to use the "Exit" button just above these instructions to receive credit for completing this course!
Exit
Edit
Next

Equal Credit for Completing Live Webinars or Online Course

1 hour Webinar

2.5 hrs self-paced Online Course




Thanks

References

Bodner, M.J., N.W Junker, R.H. Grumm and R.S Schumacher 2011: Comparison of Atmospheric Circulation Patterns during the 2008 and 1993 Historic Midwest floods. NWA,December 2011.

Junker, N.W., R.H. Grumm,R.H. Hart, L.F Bosart, K.M. Bell, and F.J. Pereira, 2008: Use of normalized anomaly fields to anticipate extreme rainfall in the mountains of northern California.*Wea. Forecasting*, **23**,336-356.

--------, M.J. Brennan, F. Pereira, M.J. Bodner, and R.H. Grumm, 2009: Assessing the Potential for Rare Precipitation Events with Standardized Anomalies and Ensemble Guidance at the Hydrometeorological Prediction Center. *Bull. Amer. Meteor. Soc.*, **90**, 445–453.

Maddox,R.A., C.F Chappell, and L.R. Hoxit. 1979: Synoptic and meso-alpha aspects of flash flood events. *Bull. Amer. Meteor. Soc*., **60,** 115-123

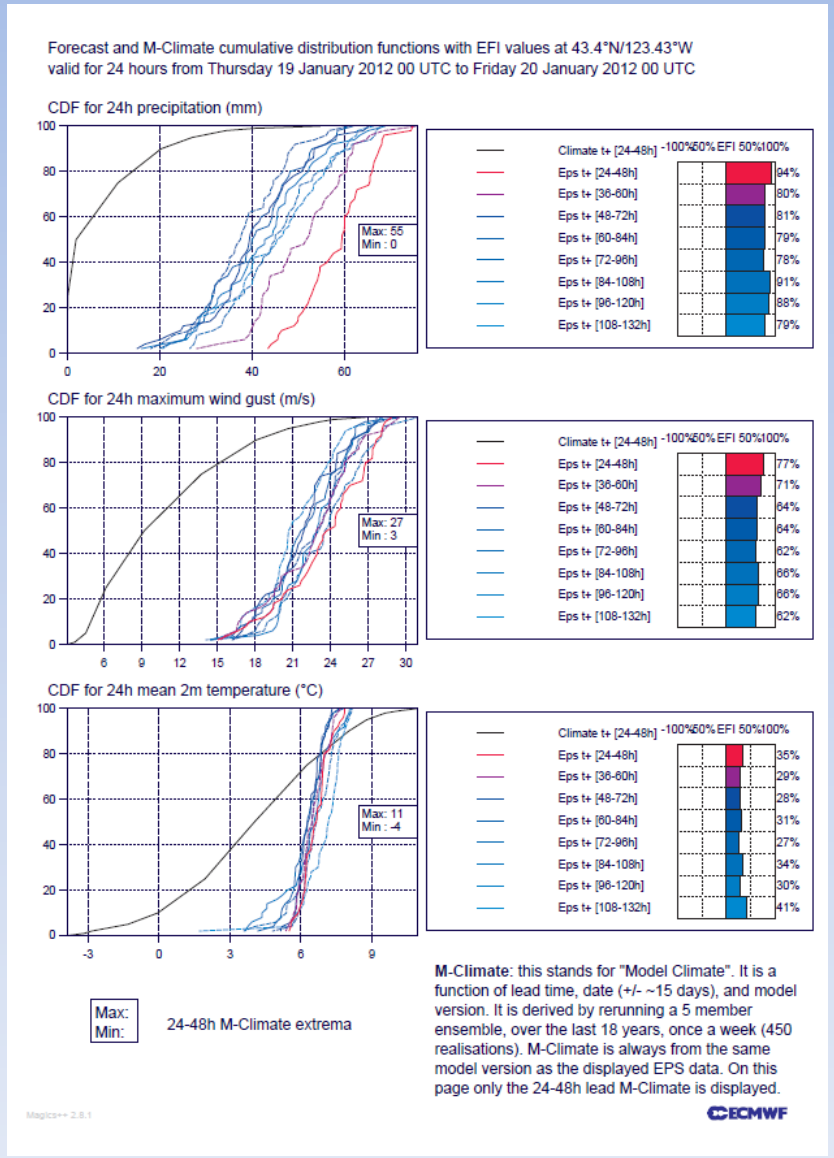
EFI Papers:

Laluarette, F. 2003: Eary Detection of abnormal weather conditions using a probabilistic extreme forecsat index. Q.J.R. Meteorol. Soc. 129,3037-3057. (See ECMWF Tech Memo 373)

Legg T.P. and K.R. Mylne, 2004: Early Warnings of severe weather from ensemble forecast information. Wea. Forecasting,19, 891-906.

Palmer, T.N. 2002, The Economic value of ensemble forecasts as a tool for risk assessment: From days to decades. Q.J.R. Meteorol. Soc. 128,747-774.

EFI at a Point
Visualize CDF of model and forecast cycles



- January 2012 cold, wind and snow western United States
- Look at QPF upper panel
  - All members show for all runs show generally higher QPF then in the M-Climate
  - EFS is predicting extreme rainfall for this point
  - ***Model forecast near record QPF internally is valuable information!***
- Winds show same effect
  - Winds are forecasting winds higher than M-Climate by most members